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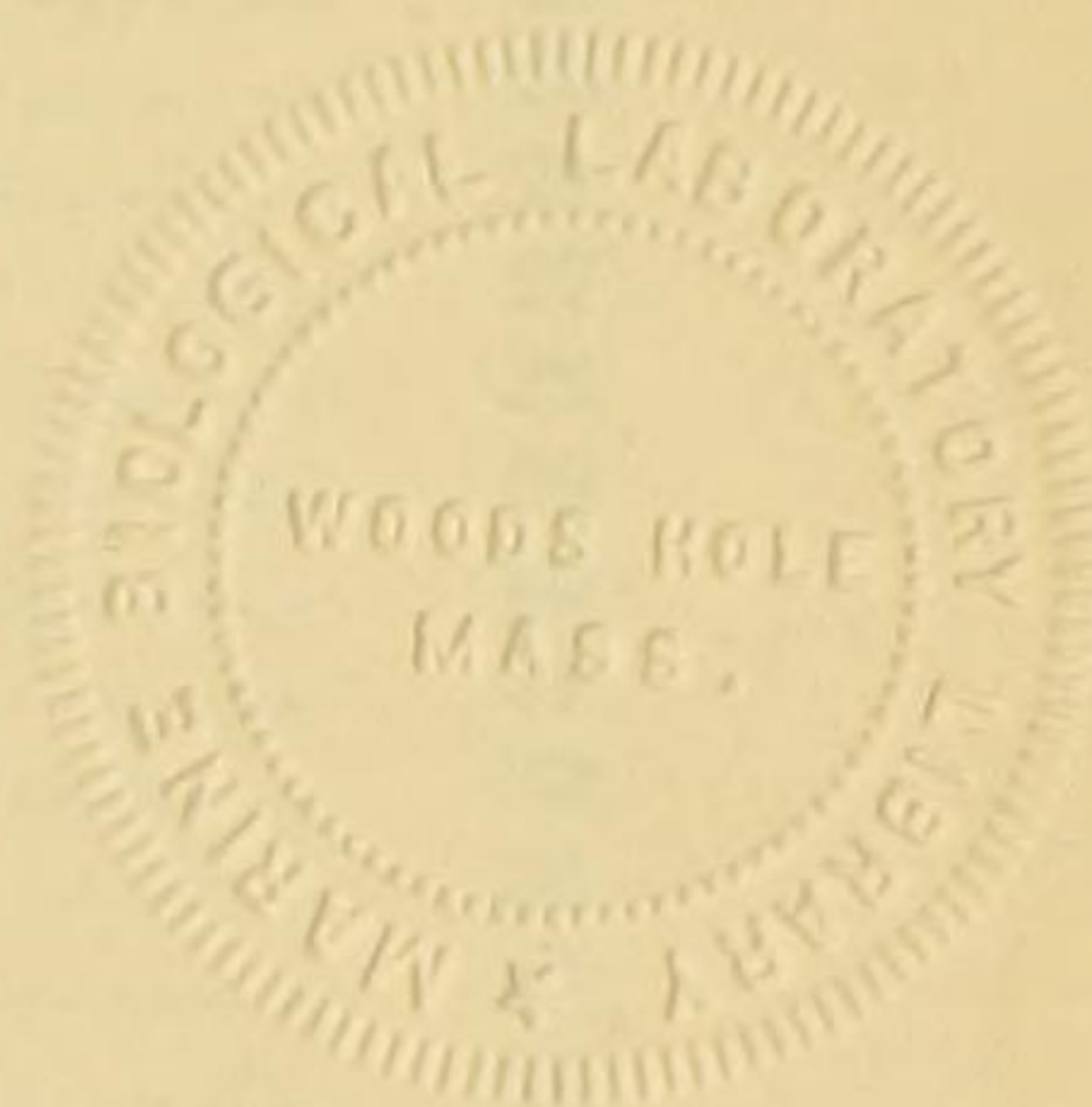
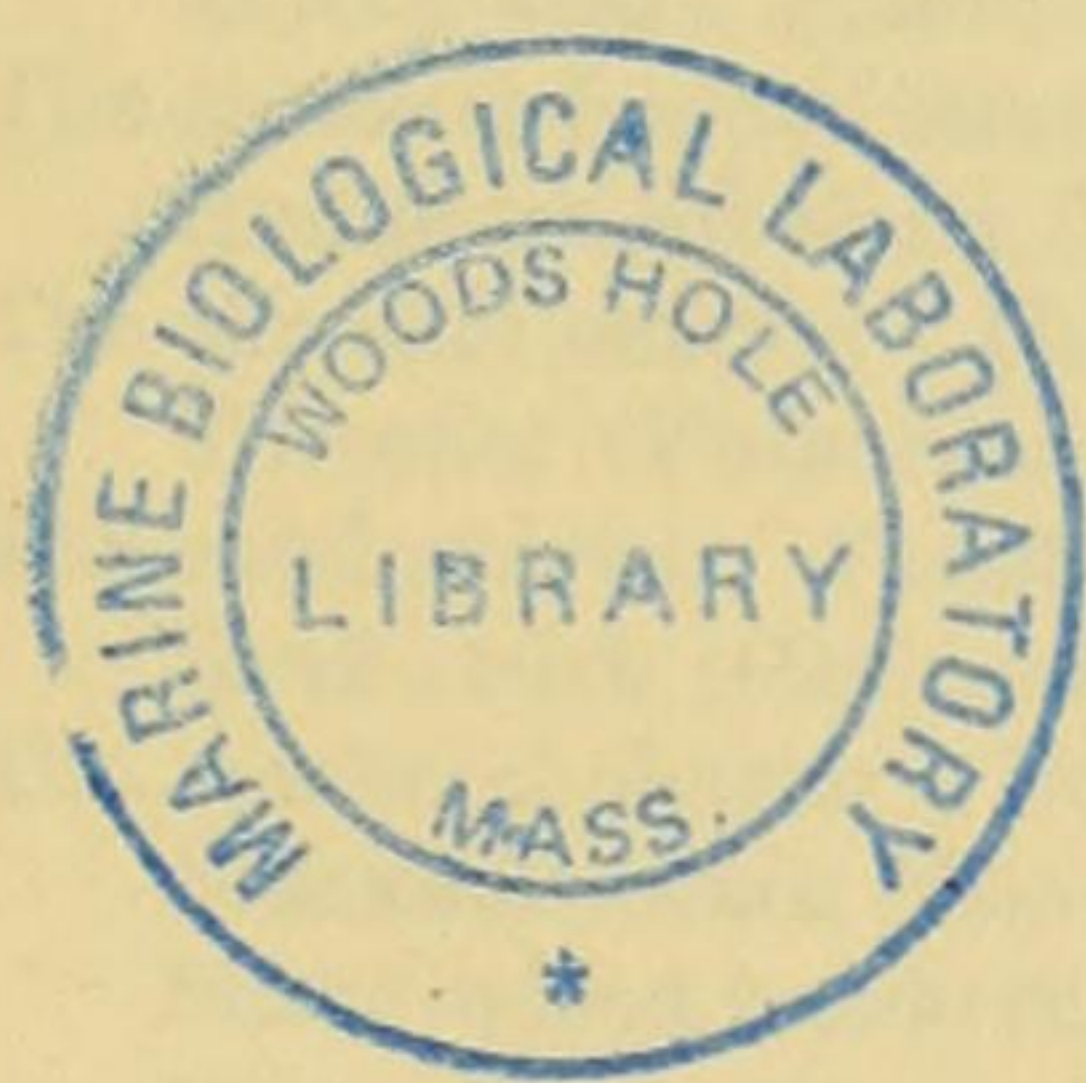
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## INTRODUCTION

In the summer of 1912 the Bureau of Fisheries, with the cooperation of the Museum of Comparative Zoology of Harvard University, undertook an oceanographic and biological survey of the Gulf of Maine, with special reference to its fishes and floating plants and animals (plankton), its physical and chemical state, and the circulation of its waters. Subsequent cruises were made on the fisheries schooner *Grampus* during the summers and autumns of 1913, 1914, 1915, and 1916, and during the winters and springs of 1913 and 1915. The work was interrupted by the war, but was resumed with a cruise of the fisheries steamer *Albatross* in the late winter and spring of 1920 and continued by the fisheries steamer *Halcyon* during the winter and spring of 1920-21 and the summers of 1921 and 1922. Several reports on special phases of the survey have been published, but not until 1920 did the body of data warrant undertaking a general account of the fish fauna, general biology, and oceanography of the Gulf, of which the present memoir is the first part.

In the division of labor the preparation of the section on the fishes was assigned to my coworker, W. W. Welsh, who had given special attention to this phase of the work throughout all the years of the survey, both on the regular oceanographic cruises and on many trips on commercial fishing vessels, in the course of which he



had gathered a large body of original observations on the growth, reproduction, diet, and other phases of the lives of many of the more important species. The report was far advanced when interrupted by his untimely death, and so much of the material had been collected that, at the request of the Bureau of Fisheries, I have undertaken to carry it to publication along the lines originally laid down, though I am unable to give it the value it would have possessed had Mr. Welsh been able to finish it.

#### SCOPE OF THE WORK

Our aim has been to prepare a handbook for the ready identification of the fishes occurring in the Gulf of Maine, and to present a concise statement of what is known of the distribution, relative abundance, and the more significant facts in the life history of each. The descriptions have been made as little technical as is compatible with scientific accuracy, and are chiefly limited to such external features as may suffice for identification in the field. As a further aid to identification, keys to all species have been provided. In every case the sizes of larval fish or eggs have been given in millimeters (1 inch equals 25.4 millimeters), but these can be easily converted into inches or parts of an inch. We have followed Garman (1913) in the nomenclature of the sharks, skates, and rays, and Jordan and Evermann (1896-1900) for all the others, except as noted. For each species we have given page references to these authors, where the reader, if interested, may find more detailed descriptions and synonymies. Most of the illustrations have been borrowed from earlier publications, but a few are original. Rules given under illustrations represent a length of 1 inch.

#### AREA COVERED

The term "Gulf of Maine" covers the oceanic bight from Nantucket and Cape Cod on the west to Cape Sable on the east, thus including the shore lines of northern Massachusetts, New Hampshire, Maine, and parts of New Brunswick and Nova Scotia. The eastern and western boundaries adopted in this paper are 65° and 70° west longitude, respectively. Southern species, recorded but once from Nantucket and which have no real status in the Gulf of Maine except as accidental stragglers, have been relegated to footnotes. The Gulf of Maine has a natural seaward rim formed by Nantucket Shoals, Georges Bank, and Browns Bank. We have chosen the 150-fathom contour as the arbitrary offshore boundary because this will include all the species likely to be caught by commercial fishermen and will exclude almost the entire category of deep-sea fishes so numerous in the basin of the open Atlantic but not constituents of the fauna of the Gulf of Maine.

The general geography of this area will be the subject of another report, but it may not be amiss to point out here that the temperature of the Gulf and its fauna as a whole are boreal, its southern and western boundaries being the northern limit of common occurrence of many southern species of fishes and invertebrates.



## SOURCES OF INFORMATION

The literature dealing with the fishes of the Gulf of Maine begins with the earliest descriptions of New England, for the fishery possibilities of the Gulf so impressed the early voyagers, even prior to the first settlement, that almost all accounts of their travels contain first-hand observations on the local abundance of fish of one species or another. Capt. John Smith (1616), for instance, commented on the abundance of sturgeon, cod, hake, haddock, cole (the American pollock), cusk, sharks, mackerel, herring, cunners, eels, salmon, and bass in 1616, while Wood (1634), in his "New England's Prospect," gives much interesting information, some of which is quoted hereafter. It was not until the early part of the nineteenth century that the sea fishes of northern New England and of the Maritime Provinces began to attract scientific attention, but since then the local faunal lists for that region have become numerous. The following, in chronological order, are the most important of these:

1850.—"Report on the sea and river fisheries of New Brunswick, within the Gulf of St. Lawrence and Bay of Chaleur," by M. H. Perley. 137 pp., 1850. Fredericton.

1853-1867.—"A history of the fishes of Massachusetts," by David Humphreys Storer. *Memoirs, American Academy of Arts and Sciences, New Series*, Vol. V, pp. 49-92, 122-168, and 257-296; Vol. VI, pp. 309-372; Vol. VIII, pp. 389-439; Vol. IX, pp. 217-256, 39 pls. (Also in book form with supplement.) Cambridge and Boston.

1879.—"A list of the fishes of Essex County, including those of Massachusetts Bay, according to the latest results of the work of the U. S. Fish Commission," by George Brown Goode and Tarleton H. Bean. *Bulletin, Essex Institute*, Vol. XI, No. 1, pp. 1-38. Salem.

1884.—"Natural history of useful aquatic animals," by George Brown Goode and associates. Section I, *The Fisheries and Fishery Industries of the United States*, published jointly by the United States Fish Commission and the United States Bureau of the Census. Washington.

1908.—"Fauna of New England. 8. List of the Pisces," by William C. Kendall. *Occasional Papers, Boston Society of Natural History*, Vol. VII, No. 8, April, 1908, pp. 1-152. Boston.

1914.—"An annotated catalogue of the fishes of Maine," by William C. Kendall. *Proceedings, Portland Society of Natural History*, Vol. III, 1914, Part 1, pp. 1-198. Portland.

1922.—"The fishes of the Bay of Fundy," by A. G. Huntsman. *Contributions to Canadian Biology*, 1921 (1922), No. 3, pp. 1-24. Ottawa.

Either at first hand or by reference to the original sources these faunal lists contain all the published locality records of the rarer species, while the last two, with a paper by Gill (1905b), give complete ichthyological bibliographies respectively for the coasts of Maine, New Brunswick and Nova Scotia, and Massachusetts. A similar list of the captures of deep-water forms along the outer part of the Continental Shelf is contained in Goode and Bean's "Oceanic Ichthyology" (1896).

The most pertinent extralimital lists are Smith's (1898) and Sumner, Osburn, and Cole's (1913) lists of Woods Hole fishes for the waters immediately to the west, and Halket's (1913) check list of the fishes of Canada for those to the east and north of the Gulf of Maine. With these readily available we have not thought it worth while to burden the present paper with the authorities for localities except in the more interesting cases. To save constant repetition we state here that almost all of the information as to the Bay of Fundy given hereafter is drawn either from Huntsman's paper or from his unpublished notes. Much information as to local



distribution and relative abundance has been gleaned from the fishery statistics published by the United States Bureau of Fisheries, the Dominion of Canada, and the Commonwealth of Massachusetts.

The literature dealing with the lives and habits of fishes occurring in the Gulf of Maine is very extensive, for most of the important commercial species, and many of the others, are common to both sides of the North Atlantic and have come within the scope of the intensive studies carried out of late years by European zoologists in conjunction with the International Committee for the Exploration of the Sea, while considerable attention has been devoted to them by American ichthyologists, also (published for the most part by the United States Bureau of Fisheries). The many scattered accounts of eggs and larvæ of northern fishes have been collected by Ehrenbaum<sup>1</sup> in his general summary of their developmental stages, a compilation the utility of which can hardly be overrated.

Among the other general European manuals, Day's "Fishes of Great Britain and Ireland"<sup>2</sup> and Smitt's "Scandinavian Fishes"<sup>3</sup> are especially helpful. We have also had access to a great amount of unpublished material in the files of the Bureau of Fisheries, especially instructive being the schedules turned in by observers who accompanied certain otter trawlers during 1913, and the observations of Vinal Edwards on the diet of fishes at Woods Hole. The superintendents of the New England hatcheries have supplied much valuable information, as noted in the appropriate connections. Dr. A. G. Huntsman has, with great kindness, contributed his unpublished notes on the fishes of the Bay of Fundy and Gulf of St. Lawrence, allowing us to quote freely from them, while Prof. J. P. McMurrich has permitted the use of his unpublished plankton records. W. F. Clapp, formerly of the Museum of Comparative Zoology at Harvard University, has contributed many interesting notes gleaned during his experience as a fisherman before his entrance into the scientific field. Harry Piers, of the Provincial Museum of Halifax, has supplied interesting notes on the occurrence of the blue shark.

We owe a debt of gratitude, also, to Dr. Samuel Garman, who has ever been ready with assistance, and to W. C. Adams, director of the division of fisheries and game of the State of Massachusetts. Finally, we wish to express our thanks to the many commercial fishermen who have unfailingly met our inquiries in the most cordial way and who supplied Mr. Welsh with a vast amount of first-hand information on the habits, distribution, and abundance of the commercial fishes, which could be had from no other source. Without their help the preparation of this handbook would have been impossible.

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<sup>1</sup> Eier und Larven von Fischen, by E. Ehrenbaum. Nordisches Plankton, Vol. I, 1905-1909 (1911), 413 pp., 148 figs. Kiel und Leipzig. (Appeared in two parts as Lief. 4, 1905, and Lief. 10, 1909.)

<sup>2</sup> The fishes of Great Britain and Ireland, by F. Day. Text and atlas, 1880. London and Edinburgh.

<sup>3</sup> A history of Scandinavian fishes, by B. Fries, C. V. Ekstrom, and C. Sundervall. Second edition revised and completed by F. A. Smitt, 1892, 1,240 pp., 53 pls. Stockholm.



### USE OF THE KEYS

The various fins and other structures mentioned in the keys are named in the accompanying outline of a haddock, and the simplest way to explain the use of the keys is to use that species as an example, running it down with the outline at hand for reference.

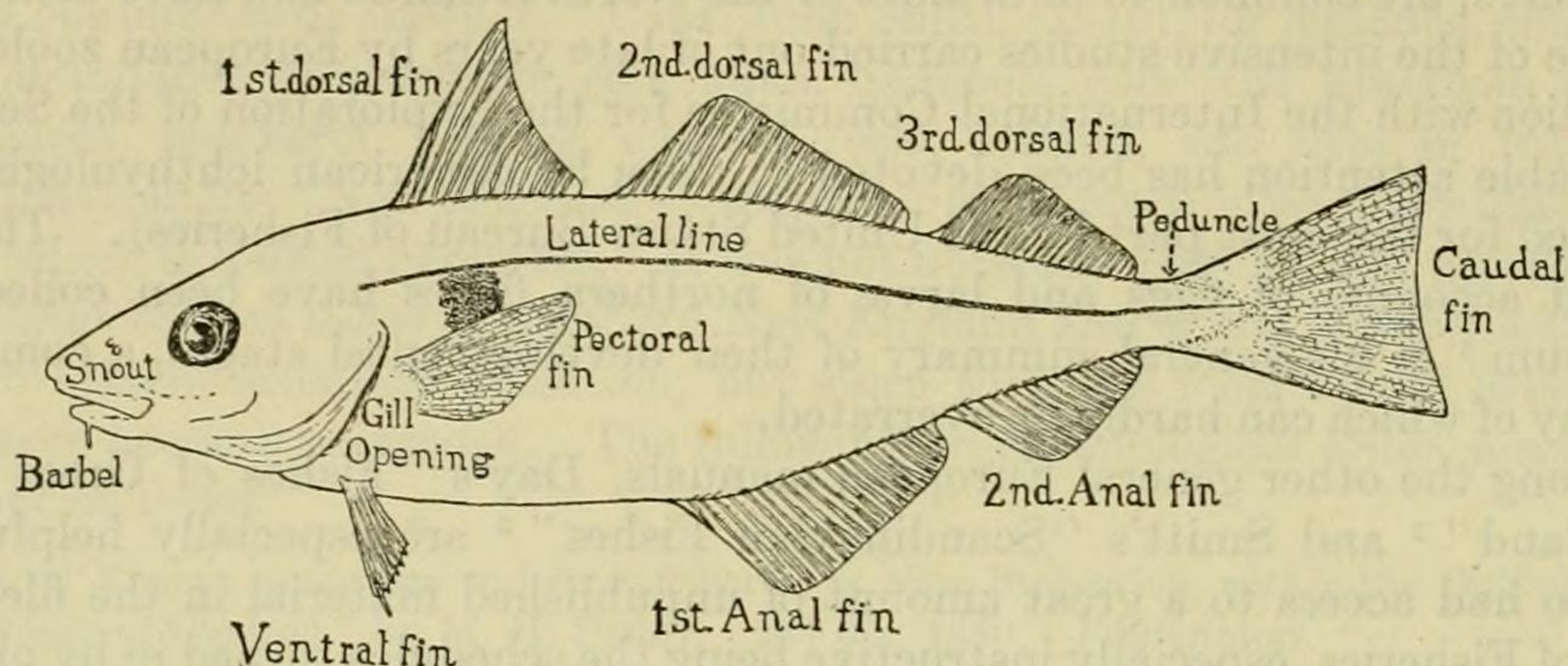


FIG. 1.—Diagram of a haddock, explaining terms used in key

Turning to section 1, Key A (p. 11), the fish in question evidently fits the second alternative, for it has bony jaws and pectoral fins and is not formed like an eel, which refers us to section 3. As our fish does not have a tubular snout this leads us to section 4, and this in turn to section 5, since neither jaw is greatly prolonged. There being only one gill opening on each side we go from section 5 to section 7, and from section 7 to section 8, for there is a distinct tail. Since the fish has no sucking plate on the top of the head this leads to section 11, and this in turn to section 12 because the tail fin is nearly symmetrical in outline. Since the fish is not clothed in an armor of bony plates we are referred by the second alternative of section 12 to section 13. In our specimen the anal fin is clearly separated from the caudal, and section 13 therefore refers us to section 14. As all the fins are supported by rays we must go on to section 15, and from there to section 18 as there are no fleshy flaps or tags on the sides of the head.<sup>4</sup> Our fish does not lie flat on one side (that is, it is a round, not a flat fish) and therefore it fits the second alternative under section 18, which refers it to section 19, and as there is more than one separate dorsal fin, this leads to Key F, page 13.

As we have already determined, all the dorsal fins have soft rays, and since there are no spines in any of the fins (a fact easily determined by feeling them), this sends us to the key to the cod and silver hake families (p. 385). Turning to the first section of the latter we find that the fish fits the first alternative (3 dorsal fins and 2 anals), which refers it to section 2, and here the black lateral line and the dark blotch on each shoulder name it a haddock.

Any other Gulf of Maine species is to be named in the same way, starting with section 1, Key A, and following through the appropriate alternatives as they refer it from section to section.

<sup>4</sup> There is a barbel on the chin but this is very different in appearance from the skin flaps around the jaws characteristic of the few species that fall under the first alternative.



first, with straight margin. The small caudal fin is demarked from the second dorsal by a deep notch; it is lanceolate in outline, terminates rearward as a short whiplike filament, and extends a short distance forward on the ventral surface of the trunk, there being no separate anal fin. The ventrals and pectorals are both triangular and pointed, the latter being much the larger and reaching back nearly to the point of origin of the ventrals. In the male the lower part of each ventral fin is modified as a trifold clasping organ. The skin is smooth, or perhaps slightly prickly, the lateral line well developed, ramifying in several branches over the head.

This species<sup>59</sup> is a close ally of the well-known chimæra of north European seas (*C. monstrosa*), but is distinguishable from it by the facts that it has no separate anal fin, that there is a considerable free space between its two dorsal fins, that the outline of the second dorsal fin is straight, that its caudal filament is much shorter, and that its pectorals hardly reach back to the ventrals.

*Color*.—Leaden all over.

*Size*.—Maximum length about 3 feet.

*General range*.—Not uncommon on the continental slope of North America from the latitude of Cape Cod northward, in 300 to more than 900 fathoms.

*Occurrence in the Gulf of Maine*.—We mention the chimæra here because one (or more) was brought in from Georges Bank some time between 1877 and 1880.<sup>60</sup> It would be no surprise to find them on the seaward slope of the bank, for halibut fishermen have often caught them off LaHave and the more easterly banks. One has even been found in the harbor of Noank (Conn.), but there is no record of it in the inner parts of the Gulf of Maine.

*Habits and food*.—Nothing whatever is known of the habits of this chimæra; little more of the northern European species except that it is a ground fish, omnivorous, eating small fish, mollusks, Crustacea, echinoderms, and worms, and that it produces large eggs with horny oval cases, bearing threadlike filaments.

## The bony fishes. Subclass Teleostomi

### THE STURGEONS. FAMILY ACIPENSERIDÆ

The sturgeons—the only Gulf of Maine representatives of the ganoid fishes—share with the sharks an uneven tail with the vertebral column extending out into the upper lobe, but there is no danger of taking one for a shark as there is but one gill opening on each side, and the gills are inclosed by bony gill covers.

#### 31. Sturgeon (*Acipenser sturio* Linnæus)

Jordan and Evermann, 1896–1900, p. 105.

*Description*.—Sturgeons are easily distinguished from all our other salt-water fishes by the fact that the head is covered by bony plates united by sutures, and the skin is armored by a row of large bony shields or bucklers along the mid-back,

<sup>59</sup> This fish is generally considered identical with a chimæra taken off the coast of Portugal, hence the choice of the specific name *affinis* instead of *plumbea*, by which the chimæra of North American waters was first known.

<sup>60</sup> Report, U. S. Commission of Fisheries, 1879 (1872), p. 788.



with two rows on each side, while the tail is of the "shark type," that is, with the axis bent upward and upper lobe much longer than the lower, and the nose is long and curiously depressed.

Each buckler bears a longitudinal keel and spine, those of the dorsal series being much larger than the others. On the average there are about 11 (10 to 16) bucklers in the dorsal row, 28 (26 to 34) in each upper lateral row, and 9 to 14 in each lower lateral row. The dorsal row extends from over the gill cover to the dorsal fin; the upper lateral from the corner of the gill opening back to the base of the tail fin; the lower lateral row from immediately behind the pectoral fin to the ventral fin, and again from the latter to the anal fin. The single rather small triangular dorsal fin is far back, its hind edge over that of the still smaller anal. The ventrals are likewise far back. The pectorals are set almost as low as the plane of the belly.

The body is elongate, comparatively slender and more or less pentagonal in cross section owing to the rows of bucklers, instead of rounded as in most bony fishes. In large fish the snout is about one-third the total length of the head (longer, comparatively, in small ones), depressed below the level of the forehead, and nearly flat beneath. The mouth, which is situated on the under side of the snout, is small and toothless (except in larval stages), with protractile lobed lips, and there are four pointed barbels in a row across the lower surface of the snout in front of the mouth.

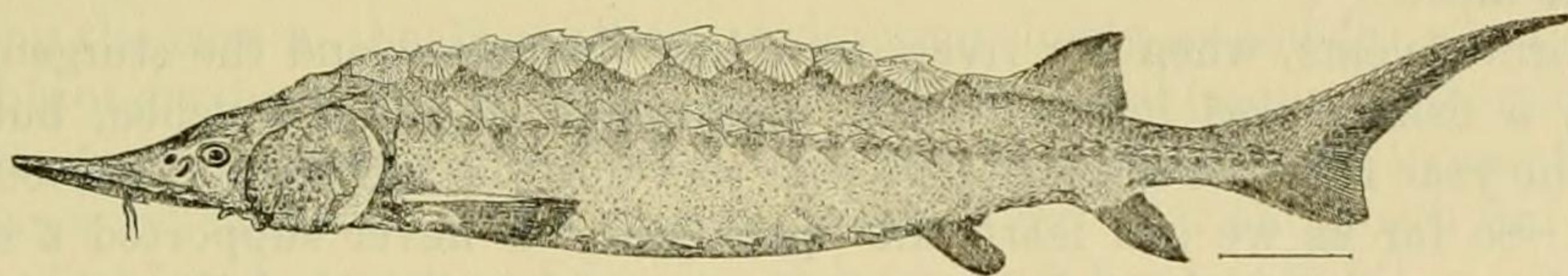


FIG. 32.—Sturgeon (*Acipenser sturio*)

*Color.*—Olive greenish or bluish gray above (in some seas reddish above), gradually fading on the sides and changing rather abruptly below the upper lateral row of shields to the white of the belly.

*Size.*—The sturgeon is a very large fish, specimens as long as 18 feet having been recorded from Europe and from New England; nor are 10-foot cows uncommon to-day in the Delaware River, where sturgeons are more plentiful than they are anywhere in New England. As a rule adults taken there run from 6 to 10 feet in length, with about 7 feet as the maximum for the males. Females weigh up to 350 pounds or more, while males average about 65 pounds in weight. Sturgeons (male and females together) averaged about 120 pounds in the Kennebec during the years when the fishery was carried on there. The fact that a fish between 11 and 12 feet long, taken near Helgoland in the North Sea, weighed 623 pounds will give an idea of the weight they sometimes attain.

*General range.*—Both sides of the North Atlantic, from Scandinavia to the Mediterranean on the European coast and from the St. Lawrence River to the Gulf of Mexico on the American coast.<sup>61</sup>

<sup>61</sup> Also recorded by Prince from Hudson Bay (Report of the sixty-seventh meeting of the British Association for the Advancement of Science, held at Toronto in August, 1897, p. 687).



*Occurrence in the Gulf of Maine.*—The sturgeon, like the salmon, shad, and alewife, is anadromous, spending most of its life and making most of its growth in the sea or in bays and estuaries, but running up the larger rivers to spawn. During its sojourn in salt water it may be expected anywhere off the coasts of the Gulf of Maine. There is definite record of it at sundry localities on both sides of the Bay of Fundy; in Penobscot Bay; Casco Bay; at the mouth of the Piscataqua River; on the Boar's Head—Isles of Shoals fishing ground, where several of from 3 to 4 feet were taken in the gill nets during April and May, 1913; both outside and in Boston harbor; off Provincetown; and off Truro on Cape Cod. It is well known in the St. John, Penobscot, Kennebec, and Merrimac Rivers, and has even been taken some distance up as small a stream as the Charles River. In fact, sturgeon once entered practically every stream of any size emptying into the Gulf of Maine. Writing of Massachusetts in 1634, Wood (1634, p. 37) described the sturgeon as "all over the countrey, but best catching of them be upon the shoales of Cape Codde and in the river of Merrimacke, where much is taken, pickled, and brought for England, some of these be 12, 14, and 18 foote long."

It is only the comparative rarity of the sturgeon in the Gulf of Maine that limits its commercial importance in the tributary rivers. In the year 1919 a total of 20,227 pounds was landed in Maine and Massachusetts. Supposing each carcass to have weighed 50 pounds (a very low estimate), this means a total of 400 fish at the most.

In former years, when our rivers were less obstructed and the sturgeons more plentiful, a fishery was intermittently maintained in the Kennebec, but as far back as the year 1880 the catch for the year was only 250 fish yielding 12,500 pounds of meat. So far as we can learn the open Gulf has never supported a sturgeon fishery, the few taken there being picked up accidentally in drift nets, traps, or weirs.<sup>62</sup>

*Habits.*—Although much attention has been paid to the sturgeon in other parts of the world because of its great economic importance, knowledge of its movements in the Gulf of Maine is of the scantiest. The large adult fish enter the mouths of our rivers sometime late in the spring in company with the salmon, shad, and alewives, slowly working their way upstream beyond tidewater before they deposit their eggs. Spawning takes place, so far as known, in May, June, and perhaps as late as July. Such, at least, is its season in north European waters, and what little is on record of its movements in northern New England is of the same tenor. It has been suggested that some may spawn in brackish water, with which the fact that females with large eggs have been taken about Woods Hole in June and July (that is, at the height of the spawning season), is in accord.

A single female fish may produce as many as 2,400,000 eggs, which hatch in about a week<sup>63</sup> after fertilization. Judging from European experiences with artificially reared sturgeon of this species, the larvæ may be expected to reach a length of 12 mm. within five days after hatching; 16 to 17 mm. at two weeks; 20 mm. at four weeks; and 4 to 5½ inches at two months.

<sup>62</sup> The short-nosed sturgeon (*Acipenser brevirostrum* LeSueur) was reported from Boston harbor and from Rockport, Mass., many years ago, but it is probable that the specimens in question were small common sturgeons.

<sup>63</sup> Ryder (Bulletin, United States Fish Commission, Vol. VIII, 1888 (1890), p. 231) has given an account of the spawning habits and early development of the sturgeon.



The old fish return to the sea after spawning, but as yet we have no idea how many years in succession a given fish may spawn or to what age sturgeons live. Apparently some of the young fish take to the sea at one year while others live for two or three years in the rivers in which they are hatched; for while sperlets of from 5 to 6 inches in length are found at the mouth of the Delaware River, as well as in the Elbe on the other side of the Atlantic,<sup>64</sup> and in the North Sea, young sturgeon as long as 18 to 20 inches are taken in winter both in the Delaware and in the Merrimac Rivers. Three marked fish in the Elbe were found to have grown as follows: The first from 17 to 38 cm. from June 17 until the following April; the second from 43½ to 64 cm. from April 9 until the following December; and the third not at all from November until the following February, suggesting that the sturgeon, like many other fishes, makes most of its growth during the warm months. By the time they have reached a length of 3 feet or so all sturgeons are either in the sea or about the river mouths, and few of them become sexually mature until they grow to about 4 feet or more in length. How long a period is covered by this growth is not known, but immature fish of from 3 to 4 feet in length are common about Woods Hole throughout the summer season, at the time when the larger ones are in the rivers spawning. We have yet to learn how far offshore sturgeons stray. They certainly descend to at least 25 fathoms, for they have been caught on cod and had-dock lines at that depth in Scandinavian waters.

The sturgeon is a bottom feeder, most abundant on sandy ground (such, at least, being the case in the North Sea), swimming slowly to and fro when at peace but capable of darting ahead like an arrow on occasion, and frequently coming up to the surface to jump clear of the water. Though so sluggish that it usually offers no resistance when netted, large ones are very strong. An old North Sea proverb has it that leaping sturgeons and dancing girls are both hard to hold!

The adult sturgeon is a mud grubber, rooting in the sand or mud with its snout like a pig (the barbels serving as organs of touch), as it noses up the worms and mollusks on which it feeds and which it sucks into its toothless mouth with considerable amounts of mud. It also consumes small fishes, particularly sand lance. Small ones, while living about estuaries and river mouths, subsist on amphipod and isopod Crustacea. Sturgeon, like salmon, eat little or nothing when running upriver to spawn.

#### THE EELS. FAMILIES ANGUILLIDÆ, SYNAPHOBANCHIDÆ, LEPTOCEPHALIDÆ, SIMENCHELYIDÆ, AND NEMICHTHYIDÆ

Eels have no ventral fins; scales are either absent or so small as to be hardly visible; their fins are soft without spines; the gill openings are very small; the vertebræ extend in a straight line to the tip of the tail; and a single fin runs over the back and forward on the belly with no separation into dorsal, caudal, and ventral portions. There are several other fishes of eel-like form in the Gulf of Maine, viz, the hags and lampreys, rock eel (*Pholis*), snake blenny (*Lumpenus*), wrymouth (*Cryptacanthodes*), eel pout (*Zoarces*), and sand eel (*Ammodytes*), but the jawless, sucker-

<sup>64</sup> Prince records a 6-inch sturgeon from Hudson Bay (Report of the sixty-seventh meeting of the British Association for the Advancement of Science, held at Toronto in August, 1897, p. 687).